Management of Posttraumatic Osteoarthritis With an Integrated Orthotic and Rehabilitation Initiative

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Abstract

Posttraumatic osteoarthritis affects approximately 5.6 million Americans annually. Those affected are typically younger and more active than persons with primary osteoarthritis. Arthrodesis is the typical management option for persons with end-stage ankle and subtalar posttraumatic arthritis. Arthroplasty is typically reserved for elderly persons. The functional limitations resulting from any of these strategies make treatment of this young population challenging. Combat wounds frequently lead to severe lower extremity injuries. We present a series of patients with severe posttraumatic osteoarthritis of the ankle and subtalar joint after combat trauma. They were treated at our institution with an integrated orthotic and rehabilitation initiative called the Return To Run clinical pathway. This clinical pathway may serve as an alternative or adjunct to arthrodesis and arthroplasty for young patients with severe posttraumatic osteoarthritis of the ankle and subtalar joint.

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This study was conducted under a protocol reviewed and approved by the Brooke Army Medical Center Institutional Review Board and in accordance with the approved protocol. The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

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Osteoarthritis (OA) is among the most common and most disabling conditions affecting adults in the United States.[1] Posttraumatic osteoarthritis (PTOA), which may arise due to intra-articular fracture or ligamentous or other soft-tissue injury, typically affects younger (<60 years), more active persons than does primary OA.[2-4] Multiple factors are believed to contribute to PTOA. Although the precise role of each factor has not been elucidated, they likely work in concert to cause end-stage joint degeneration.[5-11] Primary OA accounts for a small portion of the total burden of ankle arthritis; in contrast, primary OA accounts for a much higher burden of arthritis in the hip and knee.[12,13] PTOA of the ankle, however, is relatively frequent; up to 80% of all cases of ankle arthritis are considered to be posttraumatic.[7,14,15] Approximately 12% of adults in the United States, or 5.6 million people, are affected by PTOA, at an annual direct cost of approximately $3 billion.[14]

In combat-wounded populations, the incidence of musculoskeletal trauma is high, particularly trauma to the lower extremities.[16,17] Several published reports have noted an increase in high-energy explosive wounding mechanisms, which frequently lead to severe neurologic, vascular, and soft-tissue compromise, with extensive contamination and fragmentation injury.[16-19] Chronic pain, nerve injuries, and volumetric

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14. ABSTRACT
Posttraumatic osteoarthritis affects approximately 5.6 million Americans annually. Those affected are typically younger and more active than persons with primary osteoarthritis. Arthrodesis is the typical management option for persons with end-stage ankle and subtalar posttraumatic arthritis. Arthroplasty is typically reserved for elderly persons. The functional limitations resulting from any of these strategies make treatment of this young population challenging. Combat wounds frequently lead to severe lower extremity injuries. We present a series of patients with severe posttraumatic osteoarthritis of the ankle and subtalar joint after combat trauma. They were treated at our institution with an integrated orthotic and rehabilitation initiative called the Return To Run clinical pathway. This clinical pathway may serve as an alternative or adjunct to arthrodesis and arthroplasty for young patients with severe posttraumatic osteoarthritis of the ankle and subtalar joint.

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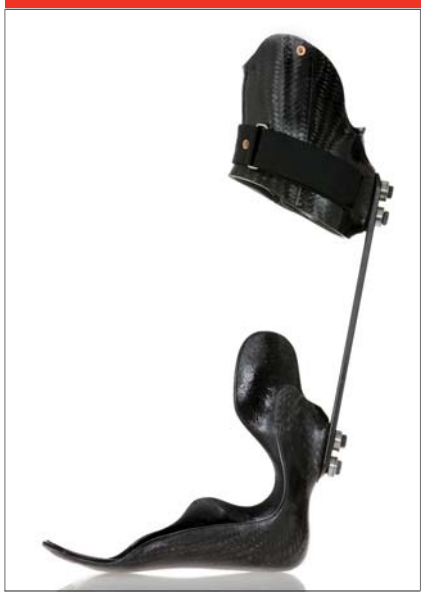
Figure 1



Photograph of the Intrepid Dynamic Exoskeletal Orthosis. (Photograph courtesy of Kara L. Carrier, Medical Photographer, Brooke Army Medical Center, Fort Sam Houston, TX.)

muscle loss frequently complicate attempts at surgical management and rehabilitation.[18-21] A substantial proportion of musculoskeletal injuries are fractures, many of which are open. In the lower extremity, the tibia and fibula are most frequently affected.[16] Musculoskeletal injuries in combat-wounded service members account for significant medical resource utilization, but more importantly, they account for most long-term disability among those who are separated from active-duty service.[22,23]

PTOA is a substantial problem in the military. One study indicated that 95% of unfitting OA diagnoses among combat-wounded service members are posttraumatic in origin.[24] Some of these patients request late amputation because of persistent disability.[25,26]

Recent reports have demonstrated the ability of combat-wounded patients to return to recreational sports activities after high-energy lower extremity trauma (HELET).[21,27] These persons participated in the Return To Run (RTR) clinical pathway. RTR is a high-intensity, sports medicine–based rehabilitation program in which participants are fitted with an Intrepid Dynamic Exoskeletal Orthosis (IDEO, Figure 1), a custom carbon fiber, energy storage and return ankle-foot orthosis.[28] Significant improvements in functional performance have been demonstrated in this primarily limb-salvage population using the IDEO compared with several commercially available orthoses ($P < 0.008$).[29] These investigations have focused on a heterogeneous patient population, and no study to date has investigated the use of such a program in patients with PTOA of the ankle and subtalar joint. We evaluated the functional, occupational, and recreational capabilities of a cohort of military service members who sustained PTOA after HELET and who are enrolled in the RTR.

Methods

The RTR database, which is not publicly available, contains information on all persons who elected to participate in the program. The database was queried for all patients who were known to have PTOA of either the ankle or the subtalar joint. Patients who underwent tibiotalar or subtalar arthrodesis before enrollment in RTR were excluded from the study. Demographic information, including sex, age, and military rank, was collected for all patients. Information pertaining to each injury, such as mechanism of injury, original injury, desire for late amputation, and surgical management, was recorded. Latency time, that is, the length of time between the initial injury and the development of PTOA, was calculated. Outcomes were divided into functional, occupational, and recreational capabilities. Functional capabilities included ambulation without assistive devices other than the IDEO, ability to run any distance, and ability to jump. Occupational capabilities included return to duty, deployment or predeployment training, ability to stand for prolonged periods of time (≥1 hour of continuous standing), and ability to move with a load weighing ≥20 pounds. Recreational capabilities included recreational running, agility sports participation, and mini triathlon participation (500-meter swim, 5-mile bike ride, and 2-mile run).

Results

To date, 91 patients have been fitted with or are in the process of being fitted for an IDEO. Of these, 15 men

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Table 1

Demographic Information on 16 Patients in the Return To Run Clinical Pathway

Patient No.	Age (yr)	Musculoskeletal Injury	MOI	Joint Affected by PTOA	PTOA Latency[a] (mo)
1	24	Open talar body and ankle fracture	MCC	TT	18
2	29	Ankle fracture	Explosion/MVC	ST	9
3	31	Bilateral tibia fracture, pilon fracture	Gunshot	TT, ST	4
4	22	Tibia fracture, multiple midfoot fractures, talonavicular dislocation, T12 burst fracture	Explosion/MVC	TT	11
5	26	Calcaneus fracture	Explosion/MVC	ST	7
6	40	Open ankle fracture-dislocation, talus fracture	Plane crash	TT	6
7	24	Bilateral ankle fracture, both-bone forearm fracture	Explosion	TT (bilateral)	11
8	33	Talus fracture, navicular fracture, hip dislocation, pelvic ring injury	Explosion/MVC	TT	10
9	25	Calcaneus fracture, talus fracture, ankle fracture, L2 compression fracture, T5 compression fracture, open finger fracture, open humerus fracture	Explosion/MVC	ST	17
10	37	Pilon fracture	MV vs Ped	TT	42
11	24	Open pilon fracture, open calcaneus fracture, talus fracture, calcaneocuboid dislocation	Explosion	ST	9
12	27	Open ankle fracture dislocation, calcaneus fracture, multiple midfoot fractures	Explosion	ST	4
13	30	Calcaneus and talus fracture	Gunshot wound	ST	7
14	26	Talus fracture, ankle fracture, multiple metatarsal fractures, ulna shaft fracture, multiligamentous knee injury, T8/11/12 superior end plate fractures	Explosion	TT	10
15	26	Open ankle fracture	MVC	TT	72
16	30	Pilon fracture, bilateral distal femur fracture, scaphoid fracture, olecranon fracture, burns to face and bilateral upper extremity	MVC	TT	26

MCC = motorcycle collision, MOI = mechanism of injury, MV = motor vehicle, MVC = motor vehicle collision, Ped = pedestrian, PTOA = posttraumatic osteoarthritis, ST = subtalar, TT = tibiotalar

[a] Latency is calculated as the time between the initial injury and the original diagnosis of posttraumatic osteoarthritis.

and 1 woman were identified as having a known diagnosis of PTOA of the ankle or subtalar joint (18%). Average age at the time of injury was 28 years (range, 24 to 40 years), and average latency time was 16.4 months (range, 4 to 72 months). All 16 subjects sustained high-energy trauma (Table 1). Six of these 16 subjects initially expressed a desire to undergo late amputation (38%). Since enrollment in the RTR, however, only one continues to request amputation. Five patients were treated with circular external fixation, and seven have undergone eight fusion procedures (four ankle, four subtalar). One patient developed tibiotalar ankylosis without surgical fusion.

Functional, occupational, and recreational capabilities are shown in Table 2. With regard to functional capabilities, 94% of the 16 patients can ambulate without assistive devices, 81% can run, and 75% can jump. In the occupational setting, 44% have returned to active military duty, 13% have deployed to combat, 100% can stand for longer than 1 hour, and 69% can move with a load of ≥20 pounds. In terms of recreational pursuits, 69% of subjects

Table 2

Functional, Occupational, and Recreational Capabilities of Patients Enrolled in the Return to Run Clinical Pathway

Patient No.	Amb	Run	Jump	RTD	D/PDT	Prol Stand	Load[a]	Rec Running	Agility Sports	Mini Tri
1	X	X	X			X	X	X	X	X
2	X	X	X	X		X		X	X	
3						X				
4	X	X	X			X	X	X	X	X
5	X	X	X			X	X	X	X	
6	X	X	X	X	X	X	X	X	X	
7	X	X				X				
8	X	X	X			X	X	X	X	X
9	X					X	X			
10	X	X	X	X		X	X	X	X	
11	X	X	X			X				
12	X					X				
13	X	X	X	X		X	X	X	X	
14	X	X	X	X		X	X	X	X	
15	X	X	X	X	X	X	X	X	X	
16	X	X	X	X		X	X	X	X	

Amb = ambulation without assistive devices, D/PDT = deployment or predeployment training, Mini Tri = mini triathlon, Prol Stand = prolonged standing, Rec Running = recreational running, RTD = return to duty
[a] Ability to move with a load of ≥20 pounds

run, 69% participate in agility sports, and 19% have completed the mini triathlon.

Discussion

Arthrodesis is the standard of care for managing end-stage ankle and subtalar PTOA. Although consistent pain relief and improved outcomes have been reported, the procedure is also associated with altered gait mechanics as well as ipsilateral foot and subtalar joint degeneration.[30-32] Long-term studies demonstrate that ipsilateral arthrosis is functionally limiting; however, most patients report that they would undergo arthrodesis again, and most would recommend the procedure to a friend under similar circumstances.[31,32] Total ankle arthroplasty is a viable option in elderly persons, but it is typically avoided in patients younger than 60 years because of concerns regarding accelerated implant wear with higher-impact activities as well as high complication rates.[2,30,33-35]

Current strategies to prevent PTOA are focused on restoration of joint congruity and stability.[3-5,9] Efforts are underway to use pharmacologic management to halt or reverse the apoptotic cascade initiated within chondrocytes following direct blunt trauma to the articular surface.[11,36] Few reports have focused on specific rehabilitation therapies for young, active patients with PTOA following HELET.[21,27,28]

Ours is the first report to investigate the nature of ankle and subtalar PTOA in high-energy military trauma. The rate of PTOA among the limb-salvage patients enrolled in the RTR clinical pathway is 18%. All patients sustained their injuries as the result of severe high-energy trauma. Most sustained multiple injuries to the lower extremities, and many had associated injuries to the contralateral lower extremity, upper extremity, and organ systems. Such severe injuries are not readily encountered in the civilian trauma setting. Despite the severity of their injuries, many persons in our cohort are returning to participation in recreational sports, returning to military duty, and deploying to combat. Nearly 40% of these patients initially requested amputation of their injured limb because of pain and activity limitations, but since being enrolled in the RTR, 83% have countermanded the request.

The prevalence of PTOA in a military population is currently unknown. In a cohort of combat casualties referred for medical separation from active-duty service, 29.6% of service members were found to have at least one unfitting condition related to arthritis.[24] Of these, 95% were directly attributable to the com-

bat injury, whereas only 5% resulted from injuries sustained before combat deployment. Nearly one quarter of the arthritis cases involved the foot or ankle, and most of the ankle injuries in the overall cohort led to unfitting arthritis.

Our patient population is unique, and the severe high-energy mechanisms of injury reported here are not typically found in the civilian trauma setting. In a retrospective series, Horisberger et al[7] reported average latency times of 40.9 years for diaphyseal tibia fractures, 21.5 years for pilon fractures, and 21.1 years for malleolar fractures. This is substantially longer than the 16 months reported here. This difference is likely the result of the higher-energy mechanisms of injury encountered in a combat environment compared with mechanisms typically seen in civilian trauma centers.

The RTR clinical pathway is currently in use only at our institution, but an effort is underway to build the capability for the program at other military treatment facilities and collaborating civilian trauma centers. The high-intensity, progression-oriented rehabilitation program challenges patients early in their recovery.[21,27,28] Performance in the program is facilitated by the IDEO. This orthosis provides a significant improvement in functional performance and is well tolerated in the short term.[29] The device is designed to off-load painful segments of the lower extremity. Because the device is custom-fabricated for each patient, the area of off-loading differs with each device.

The RTR clinical pathway has been in operation for only 2 years, and the long-term effects of wearing the IDEO and participating in this rehabilitation program are not well understood. In particular, it is not known whether long-term off-loading of painful segments of the limb may accelerate or decelerate adjacent joint degeneration. Despite this limitation, we believe that this structured multidisciplinary approach, which requires close collaboration between orthopaedic surgeons, physical therapists, and orthotists, provides an interesting alternative to arthrodesis and arthroplasty in young, active patients with PTOA of the ankle and subtalar joint.

Summary

PTOA is a substantial problem in US civilian and military populations. Arthrodesis and arthroplasty are not always desirable in the young, active patient with PTOA of the ankle or hindfoot. Use of an integrated orthotic and rehabilitation initiative in combat-wounded military personnel has allowed many of these patients to return to military duty and recreational sporting activities. Additional effort should be directed toward rehabilitation and improved orthotic strategies to maximize the functional performance of these patients. Further prospective study of this treatment protocol in a large, civilian population may provide valuable insights into the optimal postoperative treatment regimen for persons with these severe injuries.

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